

A STUDY ON RECENT ADVANCES ON ANT COLONY OPTIMIZATION ALGORITHM

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ABSTRACT

The Ant Colony Optimization (ACO) is a meta-heuristic approach to deal with hard combinatorial optimization problems. The fundamental factor in an ACO is a solution construction mechanism. It apes the decision-making processes of ant colonies as they hunt for food and find the most easily possible routes in a shorter span from their nests to available food sources. This paper is a review report on need of literature survey along with finding solutions to ant colony optimization with its algorithms in chronological order to find how advanced investigations help the process.

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INTRODUCTION

In any research work, review of literature deals with a study of the background, aims and objective of work done by various researchers. This study gives an insight into the research been done in the related areas. This explores various research articles related to SVM and parameter optimization using ACO and also helps young researchers in exploring further possibilities of research in the related areas.

1.1 Objectives of the Review

The following are the objectives of the review of related literature.

- (1) To study the researches which have been done before the current research.
- (2) To comprehend the various aspects and the scope of research.
- (3) To avoid repetition of the researches done.
- (4) To broaden the researcher's horizon of knowledge.
- (5) To explore various possible directions for research.
- (6) To acquire knowledge on Ant colony optimization and its applicability on SVM parameter setting.

REVIEW OF CONCEPTUAL ASPECTS OF ANT COLONY OPTIMIZATION

ACO algorithms might belong to various classes of approximate algorithms. From Artificial Intelligence (AI) perspective, ACO algorithms are considered as one of the most fruitful elements of swarm intelligence. The aim of swarm intelligence is a plan on multi-agent systems by taking inspiration from the combined behavior of social insects for example ants, termites, bees and other animal societies such as flocks of birds or fish schools. To quote an example for cemetery building behavior motivates “swarm intelligent” algorithms other than ACO and dynamic task allocation is greatly stimulated by the behavior of wasp colonies and Particle Swarm Optimization.

Dorigo et al., (1996) ^[1] first familiarized Ant Colony Algorithm (ACO) based on meshing strategy ACO algorithm which is stimulated by the observation of relevant colonies. It was described that the Ants exchange information through pheromone and also concluded that ant behavior is determined by the size of pheromones density. It was said that ants also create a certain amount of pheromone to influence on the surrounding environment. The ants do this activity to lay an indirect communication via pheromone trails to enable them to find the shortest possible tracks between the nest and food sources. A single ant makes appropriate choices according to its environment. The behavior of single ant is haphazard, but the behavior of groups formed after exchanging information is highly ordered. On obtaining the initial solution, ACO does not have a strong dependency and the information exchanges and passes between individuals. Its optimistic response mechanism is more encouraging to find a better solution, and it owns the global optimization and empirical optimization characteristics.

THE RESEARCH STUDIES CONDUCTED ON ANT COLONY ALGORITHM

Kucukkoc and Zhang (2015) ^[2], studied that there are several aspects which have an impact on the performance of a complex production system. Competence of an assembly line is one of the vital factor as assembly lines are usually created as the last stage of a whole production system. Parallel two-sided assembly line system is a new research area in academia although these lines have been utilized to produce large sized goods such as automobiles, trucks, and buses in industry for various years. Corresponding two-sided assembly lines cart practical benefits of both parallel assembly lines and two-sided assembly lines. The authors introduced type-E parallel two-sided assembly line balancing problem for the first time in the literature have suggested a new ant colony optimization based method for resolving the problem. The authors proposes to minimize two contradictory goals, namely cycle time, number of workstations and at the same time recommends a mathematical model for the formal description of the problem. The authors claim that this is the first study which reports both conflicting objectives on a parallel two-sided assembly line alignment. The established ant colony optimization algorithm is exemplified with an illustration to elucidate its processes. An investigational design is also conducted to standardize the parameters of the anticipated algorithm with response surface methodology. Obtained results from the performed computational study show that minimizing cycle time along with number of workstations help in escalation of system competence. It is also observed that the suggested algorithm finds hopeful results for the

researched cases of type-E parallel two-sided assembly line balancing problem when the outcomes are equated with those obtained from other three renowned heuristics.

The study by Prakasama and Savarimuthu (2015) [3], solves combinatorial optimization problems. There is an increasing necessity on metaheuristic algorithms. The research discusses the various metaheuristic algorithms with their resemblances, variances and how Ant Colony Optimization algorithm is much more apt for providing a generic implementation. Initially the study began on Travelling Salesman Problem using Ant Colony Optimization (ACO) to bring in without making considerable changes in the implementation using Knapsack Problems. It was used to display how Polynomial Turing Reduction assists to solve Job Shop Scheduling and Probabilistic nature of metaheuristic algorithms. Specifically ACO aids to a larger extent in avoiding parameter fine-tuning. It is viewed that ACO shows better resilience to change in parameter values through Sensitivity analysis compared to other metaheuristic algorithms.

Shyama and Kumar (2015) [4] conducted a study on Convoy Movement Problem which is a network optimization problem. It entails routing and scheduling military convoys between specific origin-and-destination pairs, obeying to certain strategic restrictions. Fundamentally, this has been an NP-hard problem. There is a practical difference in obtaining exact solutions for even the problems of modest size. The work examines the efficacy of Ant Colony Optimization (ACO) on Convoy Movement Problem (CMP) as there is hardly any work related to the usage of ACO algorithms on CMP in the literature. The proposed version of ACO considers multiple ant colonies and introduces penalties while apprising the trail along with the objective function whenever there is a violation of certain limitations. In this present algorithm, a separate ant colony with exclusive pheromone deposits is assigned to each convoy and consequently the trail of each colony is updated, ignoring the pheromone trails of other colonies. The results obtained from this technique are quite promising for a good number of problem instances. To measure the relationship between the number of ants present in each colony, quality of the final solution and the computational time, a sensitivity analysis is performed. Choosing less number of ants results in less computational time, but it is a trade-off against quality of the solution.

Asakura et al., (2013) [5] propose a map construction system for disturbed disaster areas created on ant colony systems. It is believed that, refugees use mobile devices to record roads they take, while leaving to a shelter as data collection agents. Recorded road information is collected and restructured at the shelter into a safe-road map. Data is assessed in concurrence with the ant colony system in this reformation. They treated the reliability of evidence on road segments pertaining to their safeness for evacuation in this method. In this simulation investigation, it has been observed that this system can follow an altering state of action and provide an up-to-minute safe-road map to a shelter in an adverse area.

As per the study of Fingler et al., (2014) [6], the Multidimensional Knapsack Problem (MKP) is considered to be a broad view of the basic Knapsack Problem with two or more restrictions. This deals with many real life applications and is an important optimization problem. They used a metaheuristic algorithm to resolve this NP-hard problem established on Ant Colony Optimization (ACO). Subsequently, several steps of the algorithm can be carried out simultaneously. The study proposes a parallel application under the GPGPU

paradigm (General Purpose Graphics Processing Units) with CUDA. To achieve quality solution from the proposed algorithm, certain parameters like number of ants, number of rounds and type of search have to be balanced carefully. In other words, there is a negotiation between time and quality of result. They acquired very hopeful experimental results when compared to those in the literature. The results showed that ant colony optimization is a feasible method to resolve MKP competently, even for large instances with the parallel approach.

Tomera (2014) [7] elucidates research based on the algorithm of PID control to optimize parameters of the ship course controller applying ant algorithm. The ant algorithm is a technique of combinatorial optimization, which uses the design of ant's exploration for the shortest route from the living place to the place where the food is found. The technique of parameter tuning for the ship course controller was applied once the controller was changing the course of the ship along with the integral action being turned off. Ant colony algorithm assesses the modified parameters of the ship course controller, which makes use of the course error based objective function and a given rudder deflection. The research has discovered that the ant colony algorithm converged very fast and in maximum cases, the concluding solution was determined in ten initial repetitions. A genetic algorithm is used to compare the results with equivalent results obtained. Furthermore, the efficacy of PID controller parameter tuning was evaluated using the ant colony optimization algorithm.

Lazarowska (2014) [8] performed a study on Swarm Intelligence application using Ant Colony Optimization techniques in a navigational Decision Support System. The capability of problem-solving in this system comprises of both path planning and collision avoidance of a ship in the main sea as well as in restricted waters. The safe ship control process is enhanced by the developed system automation. It can also be engaged in Unmanned Surface Vehicles control system that contributes to improvement of their self-sufficiency. Certain issues like navigational Decision Support System architecture, path planning and collision avoidance problem description have been presented. It also reflected on Ant Colony Optimization principles and based algorithms that is executed in navigational decision support system supports standard results, conclusions plans for advanced investigations discussed.

Kiatwuthiamorn and Thammano (2013) [9] presented a study of some interesting problems that have acknowledged significant attention over the last decade. To find an optimal solution several metaheuristic methods have been anticipated and applied successfully on various datasets. The merits and demerits of the methods were presented. The authors proposed an advanced natural behavior of the ant colonies based on optimization method. The projected algorithm, is based on the worker ants that are employed locally for searching a better solution, while the marriage, breeding, and feeding behaviors are used in replica of the new generation with foraging behavior. This algorithm has been assessed on five benchmark functions and the results bring out the efficiency of the recommended algorithm.

Braun et al., (2015) [10] in their work tackled on the inverse problem of identification of structural stiffness coefficients of a hampered spring-mass system. To solve this problem, the authors used various versions of Ant Colony Optimization metaheuristic solely or coupled with the Hooke-Jeeves local search algorithm. To deal with the continuous domain

design variables composed of different pheromone evaporation, deposit strategies and frequency of calling the local search algorithm, the assessed varieties of Ant Colony Optimization based on a discretization procedure were used. Noiseless and noisy synthetic experimental data presuming a damage alignment all through the structure were used to assess the damage approximation. When both rank-based pheromone deposit and a new heuristic information based on the search history were used, the reported results showed the hybrid method to be one of the best choice.

Koushik et al., (2013) ^[11] surveyed to see that the vehicles get their visit on the specified customer locations exactly once using the Multi-Depot Vehicle Routing Problem (MDVRP) that involves the minimizing of the total distance traveled by vehicles originating from numerous depots. This present problem pertains to a class of Non-deterministic Polynomial Hard problems and it has been used in literature as a yard stick for development of optimization schemes. The work specially deals the objective to reduce the tour length of the vehicle traveling the lengthiest distance in MDVRP using an alternative of MDVRP, called min-max MDVRP. Min-max MDVRP has a specific significance for time-critical requests such as emergency response, where one wants to minimize the time taken to attend any customer and this is evidently dissimilar from the traditional MDVRP. Initially, the work dealt with the algorithm that solves the min-max version of SDVRP, followed by min-max MDVRP by means of a reasonable region separating approach, which is meant to allot client positions to depots and facilitate MDVRP being reduced to multiple SDVRPs. For obtaining results the assessed technique has been executed in MATLAB for the min max MDVRP with any number of vehicles and customer locations. In regard to a currently available Linear Programming (LP) based algorithm, the proposed algorithm's performance is evaluated based on optimality of solution. Based on replication studies and statistical assessments, the authors proposed that the ant colony optimization technique studied in the research leads to optimal results as compared to the LP based method.

In a research conducted by Mahi et al., (2015) ^[12], the Traveling Salesman Problem (TSP) is considered to be one of the regular test problems used in performance analysis of discrete optimization algorithms. The Ant Colony Optimization (ACO) algorithm is one among heuristic algorithms operated for resolving discrete optimization problems. The authors worked on a new hybrid method that is suggested to optimize parameters that influence the performance of the ACO algorithm by means of Particle Swarm Optimization (PSO). Furthermore, 3-Opt heuristic technique is added to the aimed method so as to develop local solutions. The PSO algorithm is used for detecting optimum values of parameters α and β used for city selection operations in the ACO algorithm and decides the significance of inter-city pheromone and distances. It is also used as an intent of recuperating city selection operations. It could succeed in solving even those that could not be enhanced due to falling in local minimums by the ACO algorithm. The study investigated on various benchmark problems taken from literature and is compared with the performance of some well-known algorithms. The results reveal that the performance of planned technique by using less ants to that of the number of cities for the TSPs is better than the functioning of assessed methods in many circumstances in terms of result quality and robustness.

ACO ALGORITHMS

Enormous amount of research work related to ACO in the recent years. A consolidated list of algorithms that have been studied as part of this review is presented in Table 1.

Table 1
ACO Algorithms

Sl. No.	Year	Algorithm	Authors
1	1991	Ant System	Dorigo.et.al
2	1992	Elitist A.S.	Dorigo.et.al
3	1995	Ant-Q	Cambardella & Dorigo
4	1996	Ant Colony System	Cambardella & Dorigo
5	1996	Max-Min A.S.	Stutzle & Hoos
6	1997	Rank Based A.S.	Bullnheimer et al
7	1999	ANTS	Maniezzo
8	2000	BWAS	Cordon et al
9	2001	Hyper-Cube A.S.	Blum et al
10	2010	ACO based Algorithm	Zhang et al.,
11	2013	Ant Colony System	Koichi Asakura et al.,
12	2013	IACO	Xu Li. et al.,
13	2014	Swarm Intelligence application using ACO	Agnieszka Lazarowska
14	2015	Ant Colony System	Ibrahim Kucukkoc and David Z. Zhang
15	2015	Travelling Salesman Problem using Ant Colony Optimization	Anandkumar Prakasama and Nickolas Savarimuthu
16	2015	ACOR	Amir Saber Mahani

CONCLUDING REMARKS ON THE RESEARCH STUDIES

Ant Colony Optimization (ACO) is a pattern for drawing up Meta heuristic algorithms for combinatorial optimization problems. A metaheuristic algorithms are a collection of algorithmic thoughts that can be expended to define heuristic methods pertinent to a wide set of different problems. The first of such kind of algorithm which can be classified within this structure was presented by Marco Dorigo in his PhD thesis in the year 1991 entitled as “Optimization, learning, and Natural Algorithms”. The study presents information on how real ants resolve problems using pheromones, and since then, many diverse alternatives of the basic principle have been described in the literature. It was designed that real ants are proficient in discovering the shortest possible path from a food source to their nest. In this process of moving, the ants deposit pheromone on the ground and follow pheromone hitherto dumped by other ants. The vital trait of Ant Colony Optimization algorithms is the amalgamation of a priori information about the structure of a promising solution with a posteriori data about the organization of previously obtained

good solutions. In Ant Colony Optimization, a number of synthetic ants shape solutions to an optimization problem and barter information on their quality through a communiqué scheme that is suggestive to the one adopted by real ants.

To discover a shortest path, the moving ants drop some pheromone on the ground, so that an ant coming across a previously performed trail can detect it and decide with high probability whether to follow it. As a result, the collective behavior that develops is a form of a positive feedback loop where the probability with which an ant chooses a path increases with the path that a number of ants previously chose.

The researcher after reviewing the above studies performed study on Ant Colony Optimization came to a conclusion of its need. This study paved way to study on how to optimize the parameters in support vector machine (SVM) which are the vital factors to influence the classification performance that was stated essential by Li et al., (2013) [13]. To conclude the parameters, Improved Ant Colony Optimization (IACO) algorithm is anticipated, and then the IACO-SVM algorithm is employed on the rolling element comprising fault detection. To renew the pheromone trail density, both the ideal as well as the horrible solutions found by the ants were also accepted and the mesh is operated in the ACO to fit to the range of optimized parameters. When the parameters in SVM optimized by Genetic Algorithm (GA), are compared with cross-validation and standard ACO methods using the experimental data of rolling bearing vibration signal it is learnt that it is utilized to illustrate the functioning of IACO-SVM algorithm. The experimental consequences demonstrated that the proposed algorithm of IACO-SVM can influence higher accuracy.

IMPLICATIONS OF THE PRESENT STUDY

Ant colony algorithm is a set inspired by the Nature. It has been utilized in solving a lot of complicated issues and finding optimal answers. On the other hand, this algorithm is tricky due to its huge calculations, resulting in the decrease of its running speed. Such a decrease is studied as a weak point for the much used algorithm.

Ant Colony System is considered to be one of the most efficacious algorithms used in combinatorial for optimization problems, like the Traveling Salesman Problem [14]. This algorithm is stimulated by the searching behavior of a colony of ants when they communicate with each other. In a community, a group of members cooperates with each other to attain a certain final goal. This method of cooperation is more advantageous than when the members act independently. An ant colony can be demarcated as a group of agents who cooperate with each other using pheromone, and interchange information based on pheromone update. The computation of collective intelligence is stimulated by the behavior of some animals like ants, termites, bees, fish and certain group of birds. In such structures, each individual transmits out a very simple act; however, the collaboration between these creatures presents a complex behavior. The collective behavior of a community is made up of a combination of its individual's behaviors in a non-linear fashion.

In other words, there is a complex relation among the individual and collective behavior in a community. The collective behavior is also focused on the relation between individuals since the cooperation is the result of the accumulation of agent's experience, which is also the result of the progress of the community. This ant colony algorithm is a procedure used to find the shortest path possible.

SUMMARY

This paper can be summarized by stating that it has very well thrown light on the purpose behind review of related literature, the research studies conducted in the area for the purpose to find a solution for shortest possible path using ant colony algorithm pursued by various scholars of Ph.D./M.Phil. degree of various universities and some articles published in educational journals by eminent educationalists. The study of all these things proved to be very much useful for my research study.

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